State of California
AIR RESOURCES BOARD

Quarterly Report to the California Legislature on the Air Resources Board's Fine Particulate Matter Program

Fourth Quarter 1999

California Environmental Protection Agency

Air Resources Board

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Executive Summary

This is the second in a series of quarterly reports to the Legislature on the Air Resources Board's (ARB) fine particulate (PM2.5) program required in fiscal year 1999-2000 budget language. This report provides background on ARB's particulate programs, and covers ARB's recent accomplishments and planned activities in program areas including health and exposure research, air quality monitoring, emission inventory development, air quality modeling, planning, and control strategy development. This report includes activities funded through specific legislative appropriations, as well as programs funded through ARB's budget. A separate annual report to the Legislature provides additional information about ARB's particulate matter monitoring program as required under Section 39619.5 of the California Health and Safety Code.

In general, we provide a retrospective look at the last quarter (October through December) and a look forward at the upcoming quarter (January through March). In each report, we will also highlight selected programs, providing additional background to put expected future activities in context. In this report, we highlight the California Regional PM10/PM2.5 Air Quality Study. Key activities from the fourth quarter include:

- At our October symposium on *Exploring New Technologies for Clean Air*, ARB Chairman Alan C. Lloyd announced a comprehensive effort to reduce emissions from new diesel engines by 75 percent beginning in 2007. To meet this ambitious goal, emerging exhaust treatment technologies such as traps, filters, catalysts, and electronic engine monitoring as well as reductions in the sulfur content of diesel fuel will be needed to reduce particulate matter and nitrogen oxide (NOx) emissions.

- In December, we kicked off a 14-month intensive field study of particulate matter in central California as part of the California Regional PM10/PM2.5 Air Quality Study. The study will significantly enhance our fundamental understanding of particulate emissions, formation, and transport. California's Central Valley has one of the most serious and complex particle pollution problems in the country, making it an excellent area for such a study. The study results will form the basis for future particulate plans and control measures. The $27 million study leverages state, local, and federal monies to fund this expansive effort.

In January 2000, ARB will consider two mobile source control measures that will reduce particle pollution. We are proposing lower emission standards for urban transit buses, including long-term standards that would require the use of zero-emitting technology, such as fuel cells, by 2010. This rule is expected to have both immediate and long-term emissions benefits for particulate matter and NOx – a precursor to particle pollution. We are also proposing lower emission standards for off-road diesel engines. These standards are based on a 1996 agreement between ARB, U.S. Environmental Protection (U.S. EPA), and the engine manufacturers and will phase in beginning in 2000. These regulations will reduce emissions of NOx and include provisions to add tighter particulate matter standards in the future if feasible.

Introduction

Particulate matter pollution is one of the most formidable air quality and public health issues facing California. Exposure to particle pollution is linked to increased frequency and severity of asthma attacks and bronchitis, and even premature death in people with existing cardiac or respiratory disease. Those most sensitive to particle pollution include people with existing respiratory and cardiac problems, children, and the elderly. Prolonged and repeated exposure can also have adverse impacts. All inhalable particles are harmful – both "coarse" particles over 2.5 microns to 10 microns in diameter and "fine" particles, those 2.5 microns or smaller.

Virtually all of California violates the state air quality standards for inhalable particulate matter less than ten microns (PM10), which includes the subset of fine particles. Several areas, both urban and rural, also violate the federal PM10 air quality standards. In 1997, U.S. EPA promulgated new federal air quality standards for fine particulate matter less than 2.5 microns in diameter (PM2.5) to complement the existing PM10 standards. The PM2.5 standards have focused attention on understanding the nature of particle pollution and finding ways to reduce it.

Under the federal Clean Air Act, states must develop plans, known as State Implementation Plans (SIP), describing how and when they will attain national ambient air quality standards. With ARB technical support, the districts prepared the required PM10 SIPs. We expect PM2.5 SIPs to be due in the 2006 to 2007 timeframe. While state law does not require local districts to prepare plans for attaining the state PM10 standards, our statewide program to reduce ozone also reduces particulate levels.

The PM2.5 standards have been challenged in court by the American Trucking Association and a number of other business and industry groups. In May, a three judge panel of the U.S. Court of Appeals for the District of Columbia returned the standards to U.S. EPA to provide a better rationale for how it selected the particular levels of the standards. U.S. EPA appealed that ruling to the full Court of Appeals; however, the court declined to reconsider the case. U.S. EPA now intends to ask the Supreme Court to review the decision. Although the PM2.5 standards remain in place, the court has prohibited U.S. EPA from implementing them. We expect that the standards will ultimately be implemented, either because U.S. EPA prevails before the Supreme Court or the agency provides the clarification requested by the court.

Unlike ozone, which is a single chemical compound, particulate matter is a complex mixture of many different species generated from a wide array of sources. Particulate matter can be either directly emitted into the air in forms such as dust and soot, or it can be formed in the atmosphere (like ozone) from the reaction of gaseous precursors such as nitrogen oxides (NOx), volatile organic compounds (VOCs), sulfur oxides (SOx), and ammonia. NOx and VOCs are also precursors of ozone pollution. Directly emitted particles are called "primary particles," while those formed in the atmosphere are referred to as "secondary particles." During some episodes of elevated particle levels in California, ammonium nitrate – formed secondarily from NOx and

ammonia emissions – can account for over half of the PM2.5 mass. Understanding how particulate ammonium nitrate is formed and how to effectively reduce it through controls on NOx and/or ammonia sources will be a critical part of California's PM2.5 program.

Sources of ambient particulate matter include: combustion sources such as trucks and passenger cars, off-road equipment, industrial processes, residential wood burning, forest/agricultural burning; fugitive dust from roads, construction, mining, and agricultural activities; and ammonia sources such as livestock operations. In general, combustion processes form fine particles, whereas particles such as dust tend to fall in the coarse range. Diesel vehicles are a significant source of particle pollution from the motor vehicle fleet. Because ozone and particulate matter pollution are caused by many of the same sources and precursors, many of the control strategies in California's Ozone SIP – particularly NOx controls – provide dual benefits for public health by reducing particulate matter as well.

In the last decade, ARB has enhanced its technical and research program for particulate matter, building the scientific foundation for the PM10 SIPs adopted in the mid-1990s. ARB is now undertaking significant additional particulate matter work, including: health and exposure research; expanded air quality monitoring; emission inventory improvement; development of improved air quality models; and comprehensive field studies. Each of these technical areas plays an important role in developing California's SIP to address the federal PM2.5 standards and strategies to meet the state standard:

- *Health and exposure research* helps us understand both the impact of exposure to air pollutants (including who is susceptible to injury and the mechanisms of injury) as well as who is exposed, for how long, when, and where.

- *Air quality monitoring* provides information on which areas violate the standards and the nature and extent of the problem.

- *Emission inventories* provide an accounting of the sources of particulate matter emissions and the quantities of emissions produced from these sources.

- *Air quality models and data analysis* link air quality monitoring and inventory data with information on meteorology and atmospheric chemistry to tell us the relationship between emissions and air quality. Once we know this relationship, we can determine how much we need to reduce emissions to meet the air quality standards. We also use modeling to understand how air pollution is transported between regions. In support of our modeling efforts, we undertake extensive field studies to obtain the intensive meteorological, emissions and air quality data needed to run the models.

- *Clean air plans* describe how and when we will attain air quality standards. Plans include the technical foundation of monitoring data, emission inventories, and air quality models, as well as a control strategy for reducing emissions.

- C*ontrol strategy development and implementation* is the critical step*.* Many ARB regulations provide multiple benefits. Because they reduce emissions of both ozone and PM2.5 precursors, these controls provide dual benefits for public health. In this step, we consider technical feasibility and cost-effectiveness as well as the socioeconomic and environmental impacts.

This report covers ARB's recent accomplishments and planned activities in each of these program areas.

Our program to characterize and control PM2.5 is closely related to two other ARB programs: the particulate diesel exhaust risk management efforts and regional haze program. In 1998, ARB identified particulate emissions from diesel-fueled engines as a toxic air contaminant (TAC). We estimate the statewide average potential lifetime cancer risk from breathing particulate matter from diesel-fueled engines to be 450 chances in a million, which represents a significant threat to public health. We are now evaluating ways to reduce the risk associated with exposure to particulate emissions from diesel engines. These risk management efforts dovetail with existing efforts to control emissions to attain the particulate matter and ozone air quality standards.

U.S. EPA recently finalized its new program to reduce the regional haze that impairs visibility in many national parks and wilderness areas. Because fine particles are a main contributor to visibility impairment, our particulate matter control program will improve visibility as well. U.S. EPA intends to align the timelines for PM2.5 and regional haze planning so that the necessary technical work can be coordinated.

California Regional PM10/PM2.5 Air Quality Study

The $27 million California Regional PM10/PM2.5 Air Quality Study will provide much of the key technical information needed to develop PM2.5 SIPs and additional particulate reduction strategies for the San Joaquin Valley and surrounding areas. This is the largest particulate matter technical study ever undertaken. Study objectives include:

- enhancing our fundamental understanding of mechanisms of particulate formation and transport;

- developing and demonstrating methods useful in formulating candidate control strategies for attaining PM10 and PM2.5 standards in central California; and

- providing reliable means for estimating the impacts of control strategies developed for PM10/PM2.5 on visibility, air toxics, and acidic aerosols and on attainment strategies for other pollutants, notably ozone.

The start of a 14-month field program in December marks a major milestone for the study. In order to address the diversity of the particle pollution problem in central

California, the field program is divided into three different elements. These include: (1) a long-term program from December 1999 through January 2001; (2) a fall episodic program in September and October of 2000; and (3) a winter episodic program in December and January of 2000/2001. Because different conditions and different sources lead to elevated particle levels in the fall and winter seasons, we are planning specific intensive monitoring programs targeting each season. The long-term program will characterize annual average concentrations and their causes. (Both annual and 24-hour particulate matter levels in the Valley violate the air quality standards.)

The field program will be conducted over a domain extending from the Pacific Ocean on the west into the Mojave Desert on the east, and from the northern Sacramento Valley on the north to the Tehachapi Mountains in the south. The field program will provide an extensive database to support data analysis and air quality modeling for use in developing plans to attain the particulate matter standards. In addition to the monitoring program, an extensive emission inventory improvement effort is underway. The improved inventory is needed for future modeling efforts and evaluations of potential control strategies. This information will be used to address the following issues:

- Evaluate whether routine particulate matter monitoring networks operated by the ARB and air districts represent population exposure under a variety of meteorological and emissions conditions. We will modify the monitoring network as needed based on our findings.

- Document the current spatial distribution, temporal variation, chemical composition, and intensity of particulate matter and precursor concentrations, as well as visibility impairment.

- Characterize regional weather patterns that determine transport and diffusion of particulate matter and its precursors. An understanding of how particle pollution is transported is needed to identify the original pollution sources.

- Characterize zones of influence and quantify particulate matter source contributions. By understanding how particular sources contribute to particulate matter pollution, we can better evaluate which sources to control.

- Quantify the sources contributing to secondary particulate matter, identify the limiting precursors, and assess the extent to which reductions in these precursors will be effective in reducing particle concentrations.

- Refine our basic understanding of the causes of elevated particulate matter concentrations and interactions among emissions, meteorology, and chemical processes.

- Evaluate and improve the performance of emissions, meteorological, and air quality simulation models, and apply these models to estimate particulate matter concentrations and test potential emission reduction strategies.

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- **Start of Field Program.** The 14-month, long-term field program started on December 1. The air quality sampling network for the long-term field program builds upon the extensive existing PM10 network as well as the new PM2.5 monitoring networks being established by ARB and air districts. This network includes more than 100 PM10 sites and 50 PM2.5 sites operating within the study area. This network is being enhanced with additional "anchor" and "satellite" sites that will operate over the duration of the field program.

  At the "anchor" sites, we are making extensive measurements of particle and precursor concentrations to track particle formation and transport. In addition to collecting traditional 24-hour average measurements, instruments at these sites will make measurements at higher time resolutions (both hourly and sub-hourly) to better study particle formation. Five of these sites are operating throughout the annual program. Urban sites are located in Bakersfield, Fresno, Sacramento, and San Jose, with a rural site located at Angiola. A 100 meter tower has been erected at the Angiola anchor site and equipped at the 2, 5, 25, 50, and 100 meter elevations with air quality and meteorological instruments.

  About 35-40 "satellite" sites will complement the anchor sites and backbone network. These sites will enhance the spatial coverage of our network, providing information about the particle concentrations in the regions between urban areas. Some of these satellite sites will also be located to measure background levels and transport of pollution into and out of the Valley.

  We have also deployed an extensive upper air meteorological monitoring network to provide data needed for modeling and transport assessments. Thirteen radar profilers and one doppler sodar are collecting continuous upper air measurements throughout the study period. These instruments measure vertical profiles of wind speed, wind direction, and temperature to heights as great as a kilometer above ground level.

Health and Exposure Research

ARB has long recognized that particulate matter is harmful and has taken a lead in research to more clearly define how particle pollution impacts the health of Californians. Extensive research programs are underway both nationally and within California to clarify some of the uncertainties regarding who is at risk, whether a truly safe level of particulate matter can be determined, the mechanism of injury and the role of specific components of particulate matter in producing harmful health impacts. ARB is also a leader in research on exposure to particles and their toxic components in indoor, outdoor, and in-vehicle environments. We also publish practical guidelines on how to reduce personal exposures to indoor and outdoor pollutants, including particles.

In our last report, we highlighted the ongoing particulate matter health and exposure studies we are funding, including the Children's Health Study, an evaluation of the health impacts of smoke, our vulnerable populations research program, a residential indoor cooking exposures study, a study of sources of personal, indoor, and outdoor particle exposures, and a project to enhance our exposure models. In future reports, we will provide updates on these studies as they reach significant milestones and on new studies we fund or conduct.

Air Quality Monitoring

ARB's air quality monitoring program provides information used to determine which areas violate standards, characterizes the sources that contribute to pollution, assesses pollution transport, and supports health studies and other research. Monitoring data also provide the ultimate check on how effective our programs are – is the air quality improving? California already has a PM10 air monitoring network with over 150 monitors located throughout the state. To assess the nature and extent of the PM2.5 problem in California, ARB and local air districts are enhancing and expanding the PM2.5 monitoring program. ARB is augmenting our existing PM2.5 monitors with new federally approved PM2.5 monitors to measure particle constituents. This effort began in 1998 and will continue for several years until our network is fully deployed. As the first step in deploying this new network, we have already placed federally approved PM2.5 mass monitors at about 75 sites across California. A separate annual report to the Legislature provides additional information about ARB's particulate matter monitoring program as required under Section 39619.5 of the California Health and Safety Code.

Monitoring of the individual species that make up particulate matter is still an emerging field, with continuous speciation measurements the greatest challenge. To develop the best speciation network, California will need to take full advantage of emerging technologies – including instrumentation that is not yet commercially available. We are participating in the development of new sampling technology and critical research in this field, including special studies to evaluate newly emerging methods not currently used in routine monitoring. With previously allocated funds, we will purchase and deploy the first round of equipment by early 2000, and phase in purchase of the remaining speciation and continuous monitors through 2001 to allow additional time to assess which technologies are the most effective.

ARB is funding several research projects to develop advanced monitoring and analysis techniques. In future reports, we will provide updates on these studies as they reach significant milestones.

- **Aerosol time of flight mass spectrometer.** ARB supported the development of the revolutionary aerosol time of flight mass spectrometers that instantaneously measure the size and chemical composition of individual particles in the air – with no need to wait for filter collection and analysis. These instruments have been used in several studies and have performed beyond our expectations, producing

new insights into the structure and composition of ambient particles. The technology allows measurements that had been prohibitively expensive or too time-consuming to be practical. Planned studies will use this technique to provide fundamental information about the formation of secondary particles as well as the interactions between natural particles (e.g., sea salt) and human-generated pollutants.

- **Remote sensing of ammonia.** Measuring ammonia emissions – both from sources and in ambient air – is technologically challenging. Using an advanced remote sensing device, ammonia emissions from complex sources, such as cattle feedlots or fertilized fields, can be more completely characterized. In addition, ammonia can be present in significant concentrations several hundred meters above the surface. With this ground-based remote sensing lidar technology, ammonia concentrations aloft can be measured. This monitoring technique will be used during the California Regional PM10/PM2.5 Air Quality Study.

- **Biological fingerprinting for dust sources.** Source apportionment models are used to relate monitored particulate species back to emission sources. However, traditional apportionment techniques cannot distinguish one type of soil dust from another (for example, dust from an agricultural field from dust from an unpaved road). Work is underway to explore the use of biochemical markers (such as fatty acids and microbial DNA) to distinguish among soil sources of airborne dust and to test these markers in source apportionment for fugitive dust. If we can distinguish the specific source of dust contributing to elevated particle levels, we can more effectively target controls to reduce emissions.

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- **PM2.5 Continuous Monitor Deployment**. We are purchasing 29 continuous PM2.5 mass monitors to add to the network. We expect to receive the samplers by July 2000 and place them in the field during the third quarter of 2000. These monitors provide “real time” continuous data which will be used to inform the public about particulate matter levels in their communities, as well as provide information on how particle concentrations vary hour by hour. Most of these samplers will be deployed in highly populated areas; however, some will support monitoring efforts along the California-Mexico border, and three will measure background levels of the air entering the state from the Pacific Ocean. We are using federal funding to purchase some of these monitors; however, because California needs more monitors than required by U.S. EPA to fully characterize particulate matter air quality statewide, we are purchasing some of the continuous monitors using funding provided by the Legislature. In addition to the 29 units mentioned above, several local districts will be purchasing and deploying ten additional units within the same timeframe.

We are also purchasing six portable battery powered nephelometers. Nephelometers measure light scattering which is caused primarily by fine particles. The instruments we selected to purchase correlate very well with PM2.5 levels and will be used for continuous PM2.5 mass measurements. Being portable, these samplers can be deployed more quickly and relocated more easily than samplers designed for permanent installation. They will be used primarily for special purpose studies and emergency deployment.

- **PM2.5 Speciation Network Design and Deployment.** We are continuing to refine the design of the PM2.5 speciation network. Speciation samplers provide valuable information about the composition (and ultimately sources) of PM2.5 pollution. Our speciation network will contain two components. First, U.S. EPA regulations require seven speciation monitors in California as part of a nationwide network. The purchase of these monitors is being funded by U.S. EPA. Because U.S. EPA wants consistency across the network so it can compare nationwide trends, it is selecting the type of samplers to be used. The second component will include additional sites to augment the required seven so we can more fully characterize particulate matter statewide. We have the flexibility to select the type of samplers for these sites. Funding from the Legislature is being used to purchase advanced technology samplers to augment some of these sites. Our 1998-1999 sampler comparison study in Bakersfield helped identify several commercially available instruments that will meet our monitoring needs. Because the technology to effectively monitor individual particulate species is still emerging, we will continue to take an incremental approach in deploying our speciation network by phasing it in over the next three years.

  - We will first establish three of the seven speciation sites required by U.S. EPA regulation. These samplers will be sited in Fresno, Sacramento, and San Jose. We expect to receive the samplers by the end of 1999 and place them in the field early in 2000. Instead of deploying all seven at one time, we will operate the first three sites to evaluate candidate samplers. (While U.S. EPA is dictating the menu of approved samplers to use for these sites, there are three types to choose from.) Based on our evaluation, we will then purchase the remaining four required samplers later in 2000. Data collected at these sites will complement the California Regional PM10/PM2.5 Air Quality Study.

  - We are purchasing eight continuous nitrate analyzers and are evaluating carbon analyzers to purchase using funds from the Legislature. Generally, nitrates along with carbon make up a majority of PM2.5 in parts of California with the worst air quality (such as the South Coast and San Joaquin Valley). Therefore, particulate nitrates and carbon are key species to monitor to better characterize the PM2.5 problem.

- We will deploy additional sites in 2000 and 2001, after we have analyzed the data already collected and further evaluated potential samplers.

- **Data Management.** We modified ARB's air quality database to store the PM2.5 data being collected. The data are now available to the public on our website at http://www.arb.ca.gov/aqd/aqd.htm. Currently, a listing of the mass measurements for each site is available. (These measurements are made every sixth day, third day, or daily depending on the site.) In the first quarter of 2000, we plan to develop summary tables that would include the top four values and the number of days over the 24-hour PM2.5 standard at each site.

- **Data Analysis**. We are reviewing PM2.5 mass data collected in 1999 to identify and resolve potential problems associated with data collection and management. In the first quarter of 2000, we will begin to refine our initial assessment of potential PM2.5 nonattainment areas in California based on the first year of data from the new network. However, because three years of data are used to make formal attainment designations, it will still be several years before we know exactly which parts of California violate the standards.

  Next quarter, we will evaluate how well the PM2.5 data collected with new federally approved samplers correlate with data from the "dichot" samplers (which we have used to measure PM2.5 for the past decade) and PM10 samplers. The dichot samplers collect coarse particles and PM2.5 on separate filters for analysis. If these data are well correlated, we will be able to use historical dichot PM2.5 data and PM10 data to estimate long-term PM2.5 air quality trends.

  We are also analyzing particulate matter concentrations by day of the week to see if there are any consistent variations in concentrations between weekdays and weekends. Because of the contribution of NOx and VOC precursors to secondary particle formation, we are also analyzing whether the variations by day of week in these precursors are evident in ambient particle levels.

Emission Inventory Development

Over the last year, ARB has embarked on a program to identify and characterize the sources of emissions of PM2.5 and its precursors. This work will lead to the development of a statewide inventory of the emissions and sources of PM2.5. The inventory will include estimates of future emissions, which consider growth and the benefits of adopted air quality programs. By accurately quantifying PM2.5 emission sources, we can better target our control strategies.

ARB's existing emission inventory includes particulate emissions estimates for directly emitted PM10. Our inventory also includes estimates for gaseous precursors, such as NOx, SOx, and VOCs. We are now incorporating emission estimates for PM2.5, as well as additional particulate precursors such as ammonia. Because PM2.5

emissions are difficult to measure and characterize, this will be a multi-year effort. By 2001, we intend to produce draft emission inventories for PM2.5 and ammonia, which can be used for identifying the most important sources of PM2.5 air pollution. These inventories are being developed in coordination with the air districts, air agencies in other states, U.S. EPA, industry, and researchers.

ARB funds a number of projects to quantify and better understand PM2.5 emissions from stationary, area, and mobile sources. In the last report, we provided a summary of some of the key projects currently underway. These include evaluations of particle or precursor emissions from fertilizer application and soils, commercial charbroiling and frying operations, vehicle travel over paved roads, wildland fires, motor vehicles, off-road diesel engines and equipment, marine and personal watercraft, and small utility engines such as those used in lawn and garden equipment. In future reports, we will provide updates of significant research milestones.

In addition, ARB is taking over the operation of the chassis dynamometer testing facility originally managed by the Los Angeles Metropolitan Transit Authority. This facility will be used to perform both engine- and chassis-based emissions tests (including PM2.5) of heavy-duty vehicles on a regular basis. (Chassis dynamometers are treadmill-like devices that test engine-vehicle combinations. Engine dynamometers test engines that have been removed from, or are not yet installed in, vehicles.) The use of chassis dynamometers that accommodate trucks and buses will allow us to measure in-use emissions from these vehicles. Previously, we had only very limited opportunities to make these types of measurements. Data will be used to update the emission inventory.

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- **Characterization of Particulate Matter Emissions from Motor Vehicles:** In November, we began an 18-month study to measure ambient emissions of ultrafine particles (less than 0.1 microns) and nanoparticles (less than 0.05 microns) from motor vehicles. Laboratory studies have shown large numbers of these very small particles in motor vehicle exhaust, raising concerns regarding public exposure and health effects. Measurements will be made on and near roadways where concentrations are expected to be highest. Both the physical and chemical attributes of particulate matter emissions from gasoline and diesel vehicles will be characterized, with an emphasis on ultrafine and nanoparticles.

- **New Research Projects for FY 1999-2000.** Based on input from our August workshop in emission inventory research, we have developed concepts for four new PM2.5 emissions research projects for FY 1999-2000 and are now in the process of identifying researchers to perform this work.

    - **Vehicle travel on unpaved roads:** This project will provide better estimates of vehicle activity on unpaved roads within California. This

information will help to correct deficiencies in how unpaved road dust estimates are currently calculated and will aid in producing more effective dust control strategies.

- **Evaluation of geologic dust near emission sources:** Based on analysis of ambient air, it appears that existing estimates of particulate matter emissions from dust sources may be too large. This project will explore how the dust from sources such as unpaved roads and agricultural fields travels in the air and how long it stays suspended. This work will help us better understand the contribution of dust sources to regional particulate levels.

- **Emissions from wood-burning stoves and fireplaces:** This project will develop better estimates of particle and precursor emissions from woodstoves and fireplaces, as well as when and where these emissions occur.

- **Emissions from agricultural burning:** This project will evaluate and improve the methods used in California to estimate particulate and other emissions from burning agricultural residues. This work will be coordinated with industry representatives and burn managers to help us better quantify the impacts of agricultural burning.

Air Quality Modeling

ARB develops air quality models and runs these models to predict how emissions, weather, and terrain influence ambient levels of pollutants, based on monitoring data, emission inventories, and atmospheric chemistry. Air quality models are also used to determine the emission reductions needed to achieve air quality standards and to evaluate the effectiveness of control strategies. Regional models are used to assess pollution transport from one area to another. These types of transport assessments are needed to ensure that necessary actions are taken in both upwind and downwind districts to meet air quality standards.

California has developed some of the most advanced photochemical models in the nation for ozone. However, the state of modeling is not as advanced for particulate matter, in part because of a lack of the extensive air quality and meteorological data needed to run modeling simulations. We are working to advance the state of particulate matter modeling for use in developing PM2.5 attainment plans and particulate matter control strategies. Data collected during the California Regional PM10/PM2.5 Air Quality Study field program will be used to evaluate and improve the performance of our meteorological and air quality models.

For attainment planning, the PM2.5 modeling analyses must show the “carrying capacity,” or how many tons of emissions each affected area can hold before it exceeds the daily or annual PM 2.5 standards. The carrying capacity for PM2.5 and precursors

determines the type and amount of emission reductions needed from new control measures. PM2.5 models will also form the basis for regional haze models to assess the impact of our control strategies on visibility in California and in downwind states.

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- **Particulate matter modeling improvements.** We are currently evaluating potential particulate matter models using data collected during a 1995 field study in central California. We have applied ARB's urban airshed model to simulate a January 1995 episode and found limitations in the model's ability to accurately simulate the formation of secondary organic particles. We have already started a research contract to address this issue as discussed below. We are also planning a collaborative project with the University of California at Davis to improve the way we model chemical reactions in the atmosphere and to make other improvements to the model. In the near future, we will evaluate the same episode with an updated version of the model.

- **Atmospheric model development research.** We are funding a research project to develop the next generation of models to better simulate the atmospheric reactions among precursors that form secondary particles. The model will include, for the first time, treatment of inorganic and organic constituents simultaneously. This research is crucial to our ability to model both the inorganic and organic fractions of PM2.5 and therefore to construct comprehensive photochemical models for SIP applications. The project began in August and will take about two years to complete.

Planning

The timeline for developing PM2.5 attainment plans (SIPs) is dictated by when nonattainment areas are designated, which in turn is dictated by when sufficient PM2.5 air quality monitoring data are available. Although California had a small pre-existing PM2.5 monitoring network, no nationwide PM2.5 monitoring network or federally approved monitor for measuring PM2.5 levels existed when the new federal standards were promulgated in 1997. In 1999, we began collecting PM2.5 monitoring data using the federal reference method for comparison to the PM2.5 standards. Three years of monitoring data are needed to designate areas as attainment or nonattainment. In addition, when U.S. EPA promulgated the PM2.5 standards, it agreed to complete its next health review of the standards prior to designating areas. That review is scheduled to be finished in 2002. Thus, we expect nonattainment areas will be designated in 2003, at the earliest. SIPs would then be due three years later – or 2006 at the earliest. In the meantime, PM10 nonattainment areas will continue implementing their PM10 SIPs. Many of the strategies in these plans reduce PM2.5 as well because PM2.5 is a part of PM10.

This schedule is still tentative – in part, due to an ongoing legal challenge to the new standards. Because the planning timelines are relatively long and deployment of

the monitoring network is not being delayed, it is likely that the legal challenge will be resolved without ultimately delaying the schedule for submitting PM2.5 SIPs. Once the court case is resolved, U.S. EPA will issue guidance detailing the specific planning requirements and timelines for the PM2.5 standards.

For regional haze, U.S. EPA intends to require visibility SIPs at the same time as PM2.5 SIPs. The new regional haze regulation also provides an alternative approach for the nine states which participated in the Grand Canyon Visibility Transport Commission (including California). These states may choose to pursue an accelerated plan submittal in 2003, based on the Commission's recommendations for improving visibility at the Grand Canyon. We expect to pursue both approaches. We will coordinate with other western states as we develop a regional haze SIP in 2003 to address our contribution to visibility impairment in the Grand Canyon region. We will address visibility concerns for national parks and wilderness areas in California in coordination with our PM2.5 SIP in the 2006 timeframe.

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- **South Coast Ozone Plan Revision.** In December, the South Coast Air District Governing Board adopted an interim revision to the District's SIP to meet the federal one-hour ozone standard. The revision strengthens the District's control strategy, providing additional near-term emission reductions and reflecting the District's adoption of over 150 tons per day of new emission reductions since 1994. The District's PM10 plan relied on the ozone SIP measures, so the revision reinforces the PM10 plan by providing the needed emission reductions earlier. This revision is an interim step before a comprehensive revision to state and local control strategies planned for early 2001. The comprehensive revision will consider the particulate matter benefits of changes to the ozone control strategy.

Control Strategy Development and Implementation

ARB develops control strategies for stationary, area, and mobile sources to reduce emissions and achieve air quality goals. The development of control strategies is based on emission inventories and modeling data, considering the need for additional reductions to meet state and federal requirements, existing controls, and technical feasibility. Control strategies are also evaluated for cost-effectiveness, and socioeconomic and environmental impacts. Our assessment of the controls needed to attain state and federal standards will include estimating the PM2.5 benefits from current and planned control programs for PM10 and ozone.

In addition to regulations, we are pursuing emission reductions from voluntary programs, such as the Carl Moyer Program. This program provides grants for the incremental cost of cleaner trucks, buses, boats, agricultural equipment, and other diesel engines. Although the program focuses on NOx reductions (which provide dual benefits for ozone and PM2.5) the technologies used may also reduce direct particulate

matter emissions. Projects that replace diesel engines with natural gas engines reduce NOx and eliminate diesel particulate emissions. Demand for project funding has been three times the available monies. Staff will provide an update on the Carl Moyer Program at the January 2000 Air Resources Board meeting.

We are reviewing all mobile source categories to determine the potential for additional emission reductions. Potential measures will be identified for the next revision to California's Ozone SIP. Although the focus of our next comprehensive clean air plan will be ozone, we will also consider the impact of future mobile source measures in reducing particle as well as ozone pollution. We plan to present a comprehensive revision to our statewide ozone control strategy to the Board in 2001.

Efforts to develop and implement control strategies to meet particulate matter air quality standards relate closely to our efforts to characterize and manage the risk associated with toxic particulate emissions from diesel engines. To assist with our risk management activities, we formed an Advisory Committee of representatives from industry, environmental groups, government agencies, and the public. We are developing a "needs assessment" to: identify the current public health impact of particulate emissions from diesel-fueled engines; assess the effectiveness of programs currently in place; and determine what technically and economically feasible strategies could be pursued to further reduce emissions. We are also developing guidelines to assist the districts in permitting new and modified stationary sources that operate diesel-fueled engines. We expect to finalize both reports in Fall 2000.

1999 Fourth Quarter Update

- **New Effort to Reduce Diesel Emissions.** At our October symposium on *Exploring New Technologies for Clean Air*, ARB Chairman Alan C. Lloyd announced a comprehensive effort to reduce emissions from new diesel engines by 75 percent beginning in 2007. We will likely rely on emerging technology such as traps, filters, catalysts, and electronic engine monitoring to reduce particulate matter and NOx in diesel exhaust. However, the key to making these technologies effective is an ultra-low sulfur diesel fuel nationwide, which enables advanced emission controls.

- **Transit Bus Standards.** We are developing lower emission standards for urban transit buses, including long-term standards that would require the use of zero-emitting technology (like fuel cells) by 2010. This rule is expected to have both immediate and long-term NOx and particulate emission reduction benefits. We will bring this proposal to the Board in January 2000.

- **Off-Road Diesel Equipment Engine Standards.** We are developing lower emission standards for off-road diesel equipment engines. These standards will be based on a 1996 agreement between ARB, U.S. EPA, and the engine manufacturers and will phase in beginning in 2000 – several years earlier than anticipated in the 1994 Ozone SIP. These regulations will reduce emissions of

NOx and include provisions to add tighter particulate matter standards in the future if technologically feasible. We will bring this proposal to the Board in January 2000. In addition, more stringent particulate matter standards for diesel, off-road equipment engines will be considered in a technical review to take place in 2001.

- **Improvements to smoke management program.** We are developing changes to improve the California agricultural burning regulations which govern growers who burn agricultural waste as well as land managers who use prescribed burning on rangelands and forests. The proposed revisions seek to minimize smoke and public health impacts from burning activities. We are proposing a locally controlled program that would consider the cumulative effects of all types of burning when districts decide how many acres can be burned each day. The Board is scheduled to consider the proposal in March.

- **Air Quality and Agriculture Forum.** On February 7, ARB will host a public forum in Fresno on *Air Quality and Agriculture: Challenges and Opportunities*. The purpose of the forum is to discuss voluntary strategies to reduce air pollution (including particulate matter) from agricultural operations. The forum will focus on opportunities in two areas – expanding incentives for cleaner engines and cutting dust emissions through land management practices.

- **Heavy-Duty Vehicle Inspection Program:** Under the Heavy-Duty Vehicle Inspection Program, inspectors conduct random roadside tests of diesel trucks to ensure that smoke emissions are within acceptable levels and that emission control devices have not been tampered with. Owners of failing vehicles are issued citations and required to make repairs. Through the end of November, we have inspected over 31,000 vehicles since the program was restarted in June 1998 (with over 6,000 inspections since our last report). These inspections have resulted in about 2,100 citations and 600 non-penalty “fix-it” tickets. The failure rate has decreased from 11 percent when the program was first restarted to a current 8.5 percent. More than 1,700 trucks and buses have been repaired to date. We have instituted a formal program to pursue those owners who are delinquent in clearing their citations in order to ensure that repairs are made. Industry acceptance of the program seems to be good, as indicated by the low rate of citation appeals – about two percent. The penalties that we collect though the inspection program are recycled back to the industry in the form of incentive programs to fund the purchase of cleaner engines.

- **Periodic Smoke Inspection Program:** The Periodic Smoke Inspection Program requires all California fleets with two or more trucks or buses to perform annual smoke and anti-tampering inspections and repair failing vehicles. The first annual self-inspections of heavy-duty diesel-powered vehicle fleets had to be completed by October 1. We have conducted almost 400 fleet audits and found a compliance rate of 50 percent. We are working with owners of noncomplying fleets to bring their fleets into compliance.